National Aeronautics and Space Administration

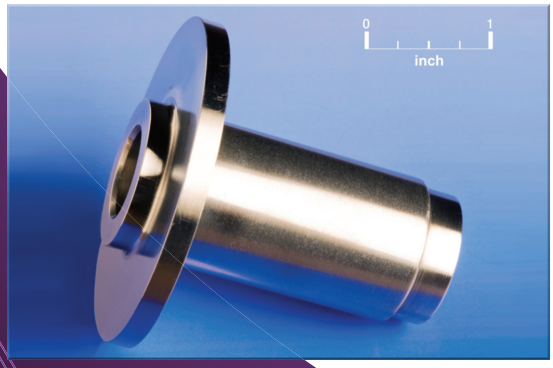
OIL-FREE TURBOMACHINERY—TRIBOMATERIALS

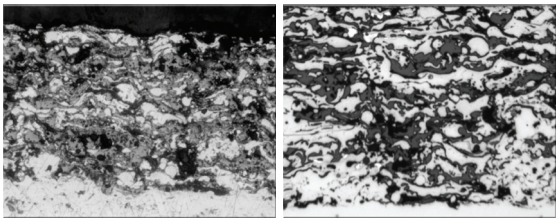
TECHNOLOGY OPPORTUNITY

NASA Glenn's Oil-Free Turbomachinery research team has developed high-temperature solid lubricant materials suitable for foil gas bearings that enable the commercialization of a broad array of revolutionary Oil-Free gas turbines, compressors, blowers, motors, and other rotating machines that can operate from cryogenic to red-hot temperatures. These tribological (friction and wear) coatings and composite powder metallurgy material innovations have immediate and proven spinoff potential for high-temperature steam turbine control valves, exhaust gas recirculation (EGR) valves, articulating ducts and piping joints, and other industrial and aerospace applications.

BENEFITS

- PS300 and more recent PS400 solid lubricant coatings provide reduced friction and wear to any lightly loaded sliding mechanism operating from cryogenic to 650+°C.
- PS300 coated shafts operating against foil bearings have logged well over 100,000 start-stop cycles without wearing out resulting in a truly maintenance-free bearing.
- NASA PS300 coatings and PM300 powder metallurgy materials and related technology are freely available in the marketplace from licensed vendors.
- The constituents (ingredients) used in NASA PS/PM 300 and 400 materials are nontoxic and thermochemically stable. They are not water-soluble and have a low environmental impact.
- PS300 and PS400 coatings and composites are protected by U.S. patents and are available for licensing to help protect your technology investment.





Comparative cross section micrographs of PS304 (left) and PS400 (right) coatings showing a similar splat layered morphology typical for thermal spray coatings.

COMMERCIAL APPLICATIONS

- NASA PS300 coated shafts enable maintenance-free, high-temperature Oil-Free microturbine electrical generators (<100 kW).
- NASA PS400 coating (simplified composition) has a lower cost and is more dimensionally stable than predecessor PS300. PS400 has been proven durable in over 20,000 hours of turbine engine operation.
- PS300 used to lubricate high-temperature steam control valve lift rods in power plants worldwide for well over a decade and PM300 bushings provide long-life service in heat-treatment furnace conveyor systems.
- PS300/400 solid lubricant technology has direct applications to any high-temperature sliding contact. Automotive exhaust as recirculation (EGR) valves and aircraft bleed air valves, high-temperature ducting, and pipe supports are just a few examples.

◀ *Turbine engine shaft coated with PS400 after grinding.*

TECHNOLOGY DESCRIPTION

Oil-Free foil bearings require innovative approaches to solid lubrication for start-stop sliding contact that occurs before the gas lubricating film forms. The PS300 and PS400 coatings and their powder metallurgy cousins are composites from a unique combination of metals, ceramics, and solid lubricant additives. Plasma spray coating deposition is used to apply a thick (0.010 inch) layer onto a metal surface that is then ground and polished before use. During rubbing contact, the lubricant phases migrate to the surface forming a lubricious glaze that prevents wear and reduces friction. Powder metallurgy techniques are used to make freestanding self-lubricating components such as bushings and wear plates whenever a coating is not convenient or possible (e.g., inside small diameter parts). These materials are made from thermochemically stable, nonsoluble, nontoxic constituents and typically include nickel, molybdenum, chrome oxide, silver, and barium fluoride-calcium fluoride eutectic. Compositions can be easily tailored for specific applications. Operation of machinery using these tribomaterials has been proven over decades of use from subfreezing to over 650 °C.

Capstone turbine engine shaft coated with PS400 after undergoing 2200 start-stop cycles and 8000 hr of high-speed and high-temperature operation. Dark shiny appearance is typical for the coating following a break-in period.

PS400 cross section sandwich samples. Top layer exposed to air at 760 °C for 15 hr. Lower layer as-deposited control coating. No microstructural or dimensional changes prove PS400's superior capabilities.

OPTIONS FOR COMMERCIALIZATION

NASA holds a patent (U.S. Patent No. 5,866,518) on the PS300 solid lubricant and has awarded nonexclusive licenses for raw materials production, powder metallurgy processing, and thermal spray coating deposition. Coating and composite samples are readily available from multiple commercial sources. A patent is pending on the more recent PS400 coating. Additional nonexclusive licensees are sought. Technical assistance for technology application is available from NASA technical and commercialization staff.

LICENSING AND PARTNERING OPPORTUNITIES

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology to and from NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Oil-Free Turbomachinery—Tribomaterials (LEW–16183–1 and LEW–18561).

FOR MORE INFORMATION

For more information about this and other technology licensing opportunities, please contact

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